* 0000800000001 * DFD

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **9701/52**

Paper 5 Planning, Analysis and Evaluation **May/June 2026**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS
- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen. Do **not** use correction fluid or tape.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION
- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.
- Important values, constants and standards are printed in the question paper.

This document has **12** pages.

DC (CE/SW) 354266/3

1 Under certain conditions, iodine forms a series of polyiodide anions with the formula I_{2n+1}^-, where *n* is an integer.

This question is about the preparation of a polyiodide salt, $(CH_3)_4NI_{2n+1}$. After preparing the polyiodide salt, the value of *n* in $(CH_3)_4NI_{2n+1}$ is found by titration.

$(CH_3)_4NI_{2n+1}$ is formed when tetramethylammonium iodide, $(CH_3)_4NI$, reacts with methanolic iodine solution, I_2(meth).

$$(CH_3)_4NI + nI_2 \rightarrow (CH_3)_4NI_{2n+1}$$

(a) Methanolic iodine solution, I_2(meth), is prepared by dissolving solid I_2 in methanol.

(i) Calculate the mass, in g, of I_2(s) needed to prepare 100.0 cm^3 of 0.300 $mol\,dm^{-3}$ I_2(meth).

mass = ... g [1]

(ii) Describe the steps taken to prepare 100.0 cm^3 of 0.300 $mol\,dm^{-3}$ I_2(meth), starting from the mass of I_2(s) calculated in **1(a)(i)** in a 50 cm^3 beaker.

Give the name and capacity of any apparatus used.

Write your answer using a series of numbered steps.

....

....

....

....

....

....

....

....

.... [3]

(b) The following steps are carried out.

step 1 Add 0.250 g of $(CH_3)_4NI(s)$ to a dry conical flask. Add 10 cm^3 of the I_2(meth) solution prepared in **1(a)**.

step 2 Carefully warm the conical flask in a water bath until no solid remains.

step 3 Allow to cool for about 30 minutes, swirling occasionally. Crystals of the product, $(CH_3)_4NI_{2n+1}$, form.

step 4 Filter the mixture.

step 5 Wash the crystals with cold methanol.

step 6 Transfer the crystals to an evaporating basin and leave to dry.

step 7 Determine the mass of dry crystals obtained.

(i) Suggest why the conical flask is **not** heated directly with a Bunsen burner in step 2.

.... [1]

(ii) Suggest why the crystals are washed in step 5.

.... [1]

(iii) Suggest how to ensure the crystals are completely dry in step 6.

.... [1]

(iv) Describe how the mass of dry crystals obtained can be determined in step 7.

Include a results table, with appropriate headings, for recording any measurements.

....

....

....

[2]

(c) 0.472 g of $(CH_3)_4NI_{2n+1}$ crystals are dissolved in 100.0 cm^3 of a solution of ethanolic potassium iodide, KI(eth). This is solution **A**.

The I_{2n+1}^- ion in $(CH_3)_4NI_{2n+1}$ is composed of nI_2 molecules and one I^- ion.
I_2 molecules in I_{2n+1}^- ions react with aqueous thiosulfate ions, $S_2O_3^{2-}$(aq).

$$I_2 + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2I^-$$

10.00 cm^3 portions of solution **A** are titrated against 0.0200 mol dm^{-3} aqueous sodium thiosulfate, $Na_2S_2O_3$(aq), to determine the amount of I_2 present in the $(CH_3)_4NI_{2n+1}$.

The titration results are shown in Table 1.1.

Table 1.1

	rough titration	**titration 1**	**titration 2**	**titration 3**
final burette reading / cm^3	14.05	27.40	41.00	13.75
initial burette reading / cm^3	0.10	14.05	27.40	0.50
titre / cm^3	13.95	13.35	13.60	13.25

(i) State what the burette is rinsed with immediately before filling it with 0.0200 mol dm^{-3} $Na_2S_2O_3$(aq) for use in the titrations.

.... [1]

(ii) Calculate the percentage error in the measurement of the titre for titration 1.
Show your working.

percentage error = ... % [1]

(iii) Use data from Table 1.1 to calculate a suitable mean titre to use in the calculations.
Show your working.

mean titre = ... cm^3 [1]

(iv) Calculate the mass, in g, of I_2 present in 100.0 cm^3 of solution **A**.

mass = ... g [3]

(v) 0.472 g of $(CH_3)_4NI_{2n+1}$ crystals were used to make solution **A** in **1(c)**. Use this information, the equation shown and your answer to **1(c)(iv)** to determine the value of *n* in $(CH_3)_4NI_{2n+1}$.

$$(CH_3)_4NI + nI_2 \rightarrow (CH_3)_4NI_{2n+1}$$

[If you were unable to answer **1(c)(iv)**, then assume the mass of I_2 is 0.374 g. This is **not** the correct value.]

Show your working.

n = ... [1]

[Total: 16]

2 This question is about the rate of the reaction between aqueous sodium ethanedioate, $Na_2C_2O_4(aq)$, and aqueous sodium peroxydisulfate, $Na_2S_2O_8(aq)$.

$$Na_2C_2O_4(aq) + Na_2S_2O_8(aq) \rightarrow 2Na_2SO_4(aq) + 2CO_2(g)$$

When $Na_2C_2O_4(aq)$ is in excess, the rate equation for this reaction is:

$$\text{rate} = k[Na_2S_2O_8]^m$$

where k is the rate constant and m is the order of the reaction with respect to $Na_2S_2O_8(aq)$.

In an experiment, excess $Na_2C_2O_4(aq)$ is added to a sample of $Na_2S_2O_8(aq)$ in a side-arm conical flask. The volume of carbon dioxide gas, $CO_2(g)$, produced is measured at regular time intervals.

Figure 2.1 shows the results from the experiment plotted on the grid. A curved line of best fit has been drawn.

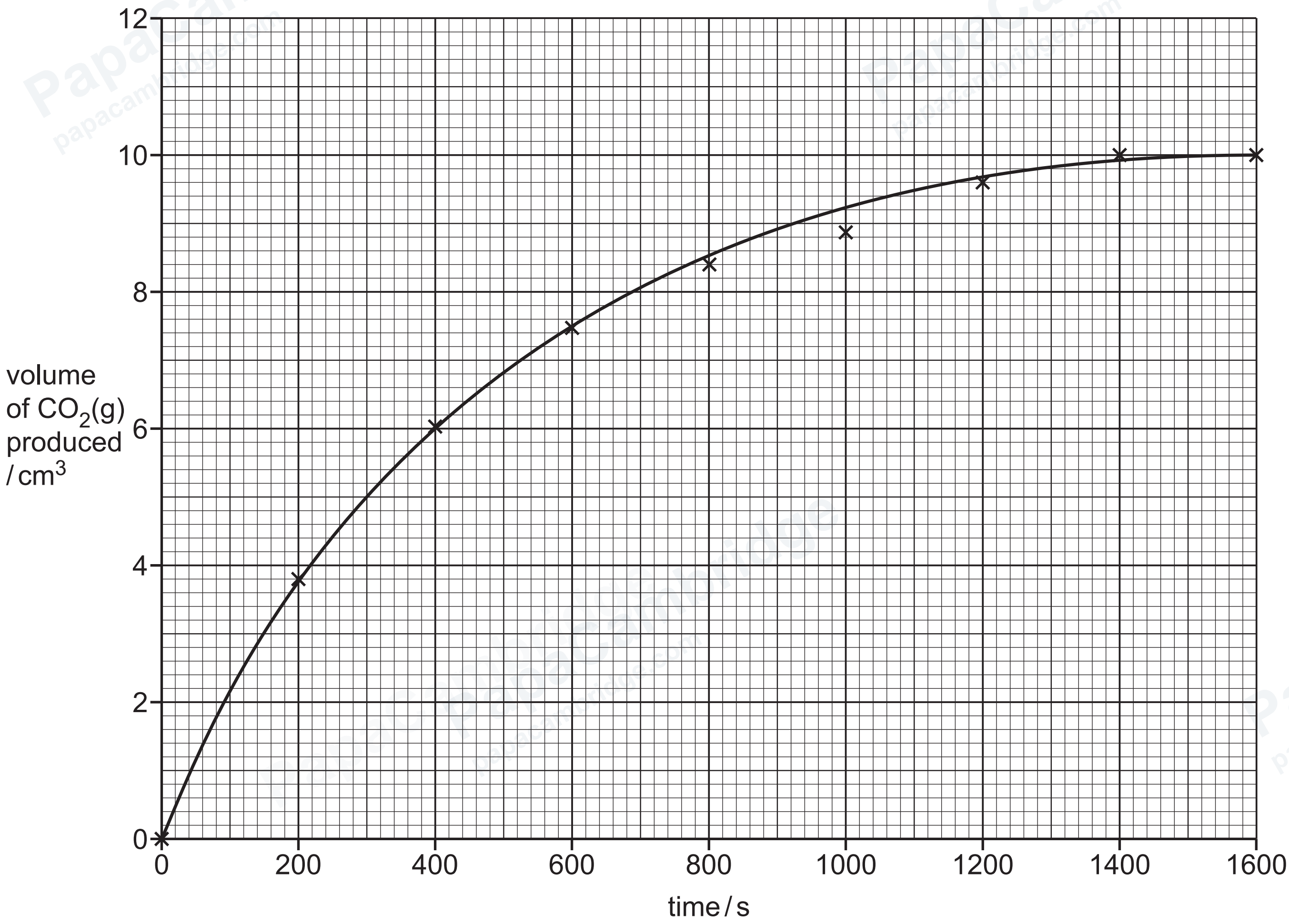

Figure 2.1

(a) Complete Figure 2.2 to show how the apparatus should be set up for measurement of the volume of CO_2(g) produced. CO_2(g) is soluble in water.
Label your diagram.

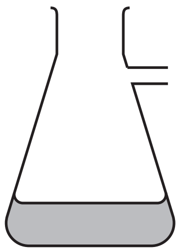

Figure 2.2

[2]

(b) Identify the independent variable.

.... [1]

(c) Suggest a timing error that could have led to the anomalous point in Figure 2.1.

.... [1]

(d) On Figure 2.1, draw a second curve to show the graph produced if the experiment is done at a higher temperature. All other conditions stay the same. [1]

(e) A student carries out the same procedure using different concentrations of $Na_2S_2O_8$. The results are used to produce the data shown in Table 2.1.

Table 2.1

$[Na_2S_2O_8]$ / $mol\,dm^{-3}$	rate / $mol\,dm^{-3}\,s^{-1}$	$\log[Na_2S_2O_8]$	log (rate)
1.00×10^{-2}	0.02760		
5.74×10^{-3}	0.01160		
3.67×10^{-3}	0.00549		
2.88×10^{-3}	0.00398		
2.08×10^{-3}	0.00250		
1.57×10^{-3}	0.00169		

(i) Complete Table 2.1.
Record your values to **two** decimal places. [2]

(ii) Use the results from Table 2.1 to plot a graph on the grid in Figure 2.3 to show the relationship between log [$Na_2S_2O_8$] and log (rate). Use a cross (×) to plot each data point.

Draw a straight line of best fit.

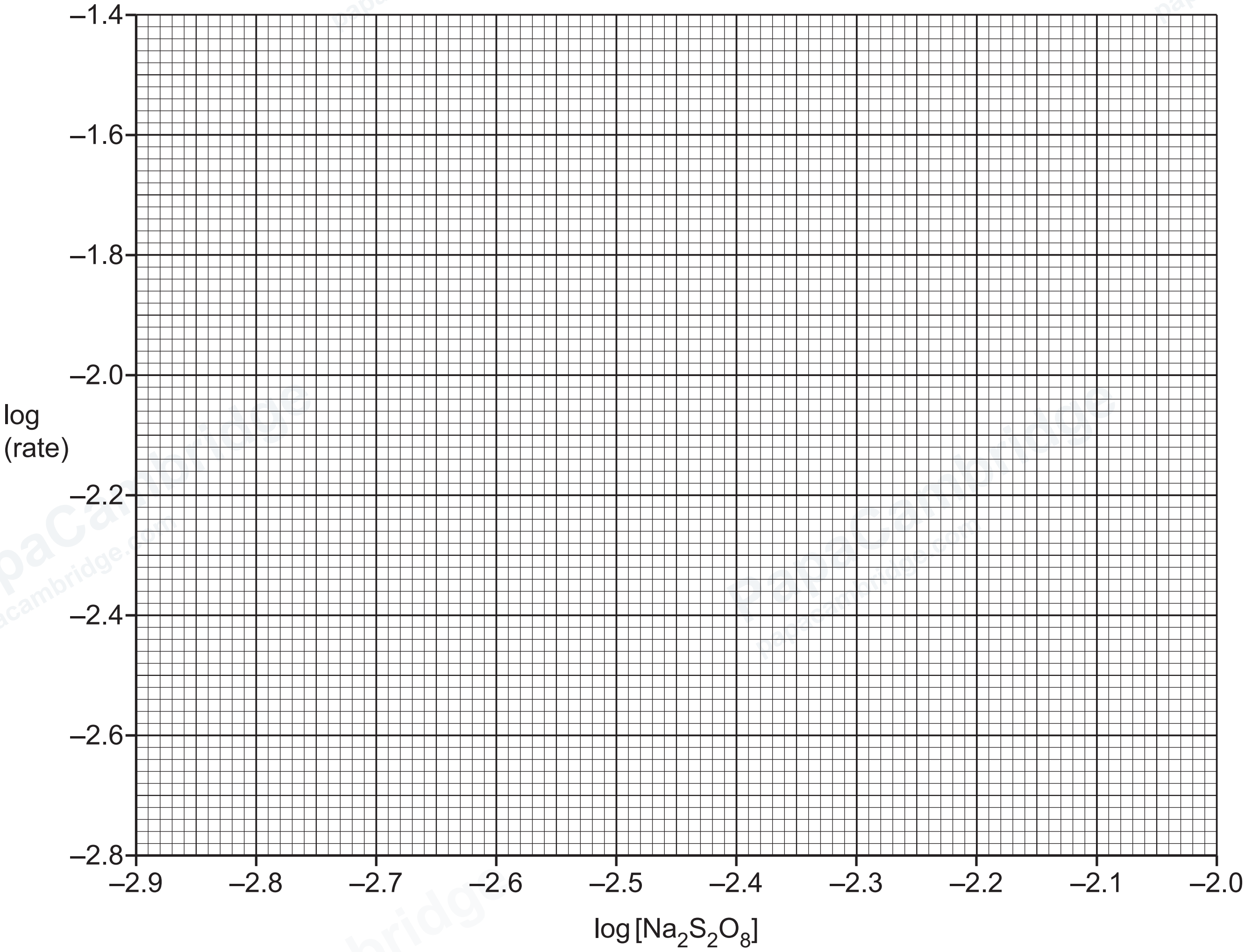

Figure 2.3

[2]

(iii) Determine the gradient of your line of best fit in Figure 2.3.

State the coordinates of both points you use in your calculation. These must be selected from your line of best fit.
Give the gradient to **three** significant figures.

coordinates 1 .... coordinates 2 ....

gradient = ...

[2]

[Turn over

(iv) The rate equation can also be written as shown.

$$\log(\text{rate}) = m \log[Na_2S_2O_8] + \log k$$

Use your answer to **2(e)(iii)** to deduce a value for k.

[If you were unable to find the gradient in **2(e)(iii)**, then use the value 1.55. This may **not** be the correct answer.]

k = ... [1]

(v) The true value for the order of reaction, m, is $\frac{3}{2}$.

The total percentage error from measurements is determined to be 4.5%.

Use this and your gradient from **2(e)(iii)** to determine whether the error in the experiment could be accounted for by error from measurements or is caused by other factors.

[If you were unable to find the gradient in **2(e)(iii)**, then use the value 1.55. This may **not** be the correct answer.]

Show your working.

....

.... [1]

(vi) Use your graph in Figure 2.3 to state whether the results from the experiment are reliable.
Give a reason for your answer.

....

.... [1]

[Total: 14]

Important values, constants and standards

molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
Faraday constant	$F = 9.65 \times 10^{4}\,\mathrm{C\,mol^{-1}}$
Avogadro constant	$L = 6.022 \times 10^{23}\,\mathrm{mol^{-1}}$
electronic charge	$e = -1.60 \times 10^{-19}\,\mathrm{C}$
molar volume of gas	$V_m = 22.4\,\mathrm{dm^3\,mol^{-1}}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0\,\mathrm{dm^3\,mol^{-1}}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14}\,\mathrm{mol^2\,dm^{-6}}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18\,\mathrm{kJ\,kg^{-1}\,K^{-1}}$ ($4.18\,\mathrm{J\,g^{-1}\,K^{-1}}$)

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The Periodic Table of Elements

Key

atomic number
atomic symbol
name
relative atomic mass

Group 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
							1 H hydrogen 1.0										2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0											5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3											13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

lanthanoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.2	61 Pm promethium –	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0
actinoids	89 Ac actinium –	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –